DOCUMENT RESUME

ED 217 255 CE 032 891

TITLE	Welding Materials. Pre-Apprenticeship Phase 1 Training.
INSTITUTION	Lane Community Coll., Eugene, Oreg.
SPONS AGENCY	Employment and Training Administration (DOL), Washington, D.C.; Oregon State Dept. of Education, Salem.
PUB DATE	79
NOTE	28p.; For related documents see CE 032 866-930 and ED 213 887-905.
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	*Building Trades; Check Lists; *Construction Materials; Job Skills; Learning Activities; Learning Modules; *Metals; Metal Working; Pacing; Postsecondary Education; Programed Instructional Materials; Tests; *Trade and Industrial Education; Two Year Colleges; *Welding
IDENTIFIERS	*Preapprenticeship Programs

ABSTRACT

This student training module on welding materials is one of three modules (see CE 032 889-890) on welding developed for Pre-Apprenticeship Phase 1 Training. (A companion instructor's guide is available separately as CE 032 888.) The modules are designed to introduce trade knowledge and skills to the student. This module contains a cover sheet listing module title, goal, and performance indicators; study guide/checklist with directions for module completion; information sheets providing details about materials used in welding and their characteristics, with related drawings; self-assessment; self-assessment answers; post assessment; and an assignment sheet. Topics covered in the module are common welding materials and their characteristics. (KC)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED2172555

INDIVIDUALIZED LEARNING SYSTEMS

PRE-APPRENTICESHIP PHASE 1 TRAINING.

WELDING MATERIALS

Goal:

The student will be able to describe common welding materials and their characteristics.

Performance Indicators:

The student will successfully complete both a Self Assessment and a Post Assessment exam.

CE032891

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

This document has been reproduced as received from the person or organization originating it.
Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

C. Horstrup

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

© Copyright 1979, Oregon Department of Education

Study Guide

This guide is to be used as a "blueprint" to complete the module. Check off the following tasks as you complete them.

1. ____ Read the Goals and Performance Indicators on the cover of this module.

2. ____ Study the Information section. This will provide you with the information necessary to go on.

3. ____ Complete the Self Assessment exam and compare your answers with those on the Self Assessment Answer Sheet.

4. ____ Complete the Post Assessment exam and turn your answers in to your instructor.

Information

The common materials used in welding are metals. Metal is an element that has all or most of the following characteristics:

- solid at room temperature (exception, mercury)
- opaque--can't see through
- conducts heat and electricity
- reflects light when polished
- expands when heated
- contracts when cooled
- usually has a crystalline structure

Most metals used in industry are not pure, but are alloys. An alloy is a metal to which another metal or non-metallic element has been added to modify the properties of the pure metal. Since pure metals are seldom found in industry, we are usually referring to an alloy when we refer to "metal."

Those metals which contain mostly iron are called "ferrous" metals. This includes ALL HIGH AND LOW-ALLOY STEELS. "Non'ferrous" metals contain little or no iron. Aluminum, titanium, brass, copper, zinc, gold and silver are all non-ferrous metals.

Metals are selected for use because of their properties. Welders must know their properties also, so that correct procedures and metals are selected to fill the requirements of the job. Properties are of two types: mechanical and physical.

MECHANICAL PROPERTIES

1. Compressive strength--the ability of a material to resist being crushed
2. Tensile strength--the ability of a material to resist being pulled apart
3. Hardness--the ability of a material to resist indentation
4. Ductility--the ability to bend, stretch or twist, without breaking. Copper or soft iron have high ductility and will fail gradually under load. Cast iron has low ductility and will crack or snap suddenly under a load.
5. Brittleness--the tendency of a metal to crack suddenly when placed under pressure.

PHYSICAL PROPERTIES

1. Density--the weight of a unit volume, such as pounds per cubic inch (lbs/in^3)
2. Resistance to corrosion--the ability of a metal to withstand the chemical action of some other material
3. Electrical and thermal conductivity--generally, the metals that are the best conductors of heat are also the best conductors of electricity. A conductor is a material that offers little resistance to electron movement. The best metal conductors are silver, gold and copper. Stainless steel is a poor heat conductor. Therefore it takes a lot more heat or electricity to melt stainless steel than to melt copper.
4. Thermal expansion--the increase in dimensions of a solid piece of metal due to an increase in temperature. This expansion is measured in terms of it's "coefficient of expansion." All metal will expand when heated and contract when cooled. This is one of the most important properties of metal in welding, because it causes distortion and must be taken into consideration when applying heat.

COMMON SHAPES OF METAL

Metals can be purchased in many shapes, and, if procured in a shape that matches the needed product, can save considerable labor and meet all of the requirements of the job. Metals come in several major shape classifications:

A. Structural and bar shapes
   1. H-Beam
   2. I-Beam
   3. Channel
   4. Angles
   5. T's
   6. Z's

B. Sheets and strips--less than 1/4-inch thick

C. Plate--1/4 inch or more in thickness

D. Hot rolled bars--bars which have been shaped while red-hot and have a blue-black oxide coating and come in many shapes:
   1. rounds
   2. ovals
   3. half-rounds
   4. half-ovals
   5. squares
   6. strips
   7. bars

E. Cold finished bars--cold steel which is pickled and then shaped; used when a fine finish is required and accuracy of size is important:
   1. rounds
   2. shafting
   3. hexagons
   4. squares
   5. flats

F. Tubing; may be:
   1. round
   2. square
   3. rectangular

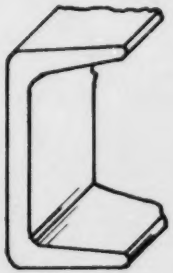
G. Pipes; may be:
   1. thin walled
   2. thick walled

(See Diagram 1, following page, for graphic examples of these materials.)

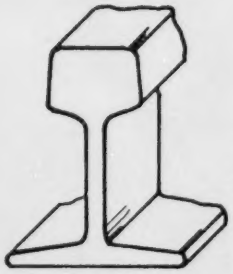
Shapes of Metals

H-Beam

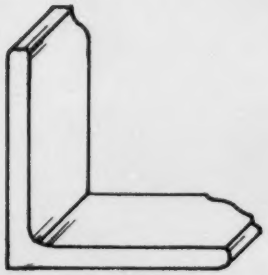
I-Beam



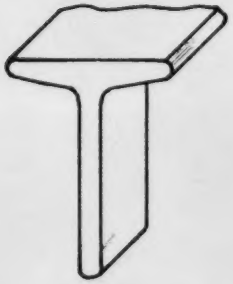
Channel



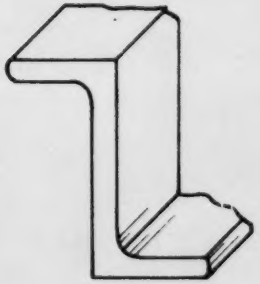
Rail



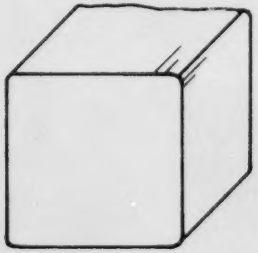
Angle



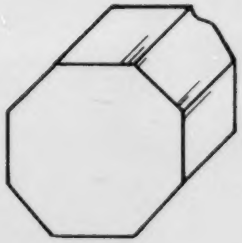
T



Z

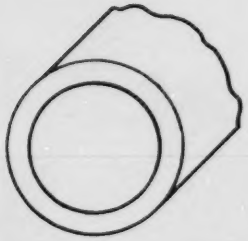


Square

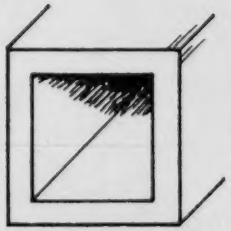


Hex

Round

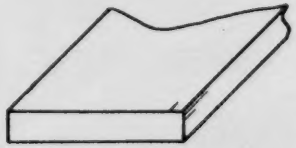


Pipe



Square Tubing

Rectangular Tubing



Bar

Half Oval

METHODS OF METAL IDENTIFICATION

Dissimilar metals are not easily welded and therefore metal identification is an important tool to the welder. He or she may use any or all of the following methods according to experience:

A. Appearance--observe the condition of surface finish, color and texture of bar stock. At first they all look alike, but with experience, differences are very soon apparent.

B. Spark Test--observe color and type of sparks from the metal being ground on the grinding wheel.

C. Manufacturer's stamp--the SAE/AISI number will be stamped on the end of bar stock.

D. Color Code--observe the manufacturer's individual color coding system for various types of metals. This color code will be painted on the end of the metal or, on stock smaller than one-inch, may be on a tag attached to the stock.

E. Magnet reaction--will separate most non-ferrous from ferrous metals. Non-ferrous metal will not show any attraction to the magnet.

F. Filing the surface--apply corner or edge to the metal and make a file cut. Observe the freshly-filed surface for color and texture, as this removes any oxide coating and exposes the true color of the base material.

(See Figures 2 and 3 on following two pages for graphics of identifying materials.)

METAL CLASSIFICATION

All steel is an alloy of iron and carbon, with other elements added to change the properties of the metals. There are two kinds of steel which are each divided into grades:

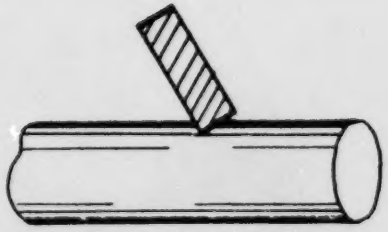
A. Carbon Steel

1. Low-carbon steel, also known as machine steel or mild steel, .05 to .30 carbon
2. medium-carbon steel, .30 to .60 carbon
3. high-carbon steel, also known as tool steel, .60 to 1.50 % carbon

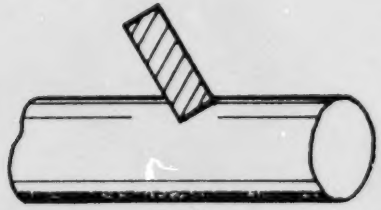
Methods of Identifying Metals

FILE TEST

File
on Edge



Hard



Soft

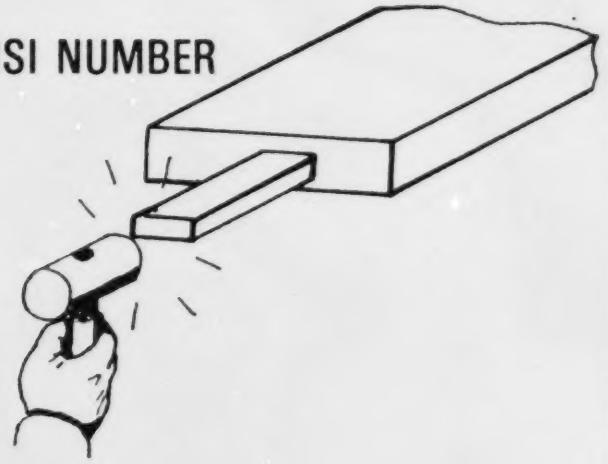
SPARK TEST

Safety Goggles

Methods of Identifying Metals

(CONTINUED)

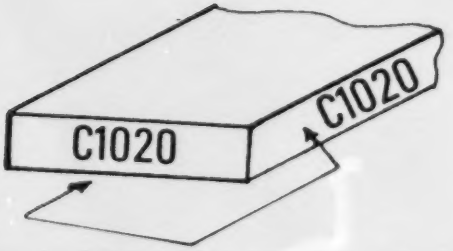
STAMP SAE/AISI NUMBER



COLOR CODING

Spray

Brush



SAE/AISI Number

B. Alloy Steel

1. Special alloy steel, such as:
   a. nickle steel
   b. chromium steel
   c. chrome-nickle steel
   d. manganese steel
   e. molybdenum steel
   f. tungsten steel
   g. vanadium steel
2. High-speed steel--contains one or more of the special alloy steels; also known as high-speed tool steel.

SAE/AISI DESIGNATION

The American Iron and Steel Institute (AISI) set up a system of steel classification for most standard steels. This system, with some modification, was adopted by the Society of Automotive Engineers (SAE). This system is based on the chemical and other alloying elements. Each metal composition is assigned a number, with both AISI and SAE using a similar number.

Each kind of steel has a number with four or five digits (usually four). The first digit tells what kind of steel it is:

1XXX is a carbon steel
2XXX is a nickle steel
3XXX is a nickle-chromium steel, and so forth

For the simple alloy steels, the second digit generally (but not always) tells the approximate percentage of the major alloy represented by the first digit. The last two or three digits tell the average percentage of carbon the steel contains in "points," or hundredths of a percent. Therefore, 3140 means that the nickle-chromium steel is about 1 percent nickle and .40 percent carbon. 52100 means that the chromium steel (5XXXX) contains about 2 percent chromium and about 1 percent (XX100) carbon.

AISI numbers preceded by a letter (E XXXX) indicate that a specific process was

used in manufacturing the steel.

AISI uses a different system for classifying stainless steel. They usually carry three digit numbers (302, 347, etc.). SAE uses the same number but precedes it with a "30" for non-hardenable nickle-chromium alloys and a "50" for hardenable alloys. Thus, AISI 304 is the same composition as an SAE 30304.

(See Diagram 4, following page, for graphic representation of designations.)

CLASSIFICATIONS OF ALUMINUM

Aluminum is assigned a four-digit number with the first digit representing the most significant alloying element. "1 XXX" series contains at least 99 percent aluminum. "11XX " contains not more than one percent of all other elements. "2000 " series contains up to almost 7 percent copper. "5000" series contains magnesium as the main alloy. "4000" series contains silicon and is used primarily as "filler" metal for welding.

The last two digits have little significance except in the "1000" series. With aluminum, the treatment it receives at the foundry is extremely important, and the final two numbers designate the "temper" of the material.

(See Diagram 5, second page following, for graphics of aluminum ID markings.)

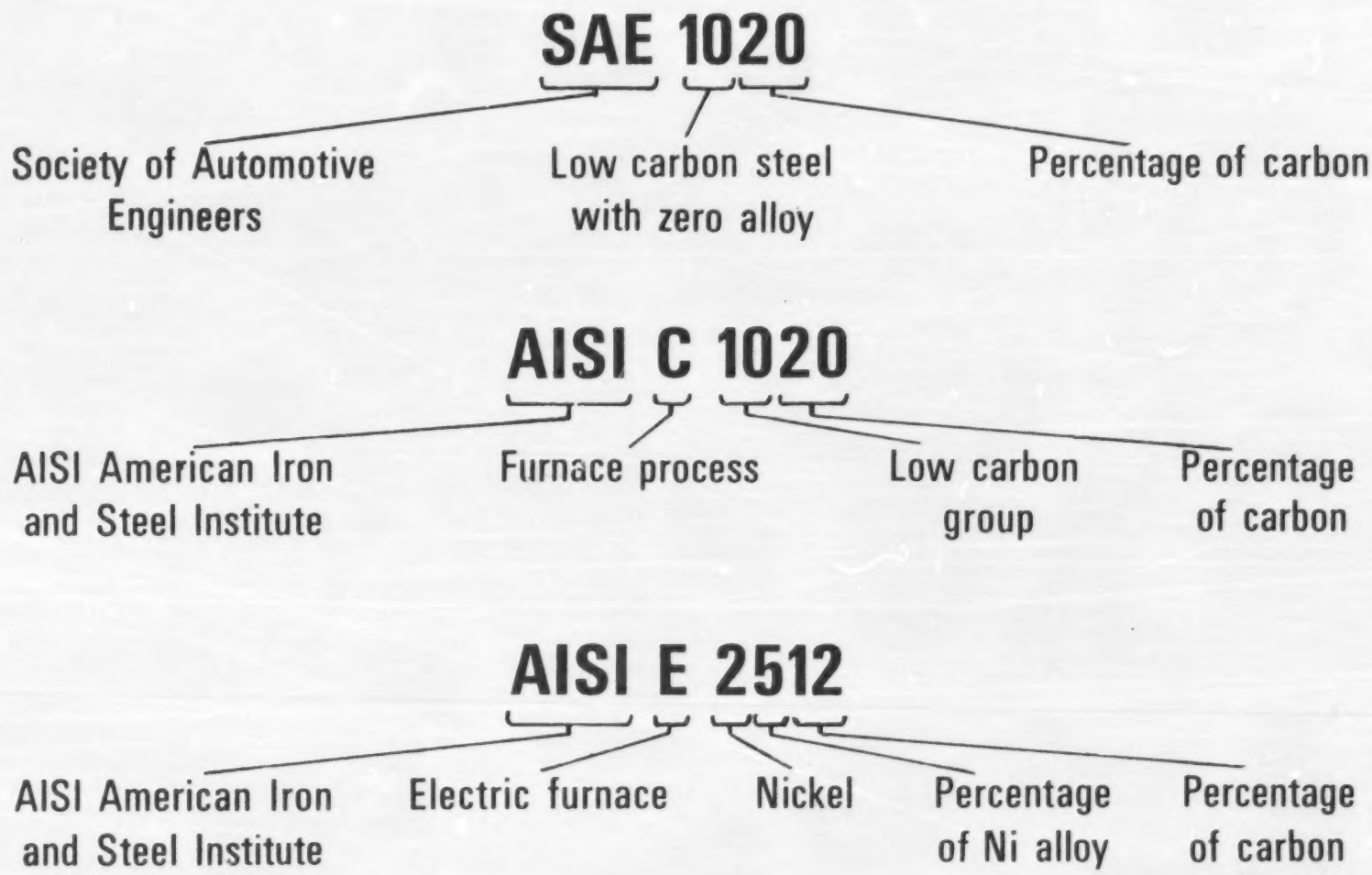
EXPANSION AND CONTRACTION

Heat causes metal to expand, cold causes metal to contract. There are two key points to remember about expansion and contraction:

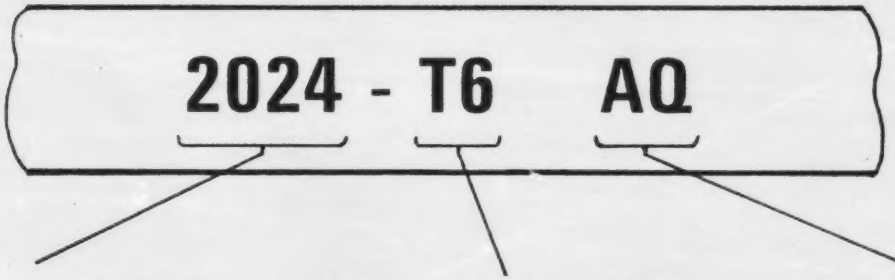
1. First, that changes will be the same in all directions if nothing restrains the expansion.
2. Second, that if expansion is restrained in one dimension, all the others will be increased, and often the changes will be permanent.

In welding operations, heat is generally applied to an edge, not to the entire piece. The cooler metal away from the edge will act as a restraint against both uniform expansion during welding, and uniform contraction during cooling. This will cause some distortion. This distortion results in bending of the metal.

SAE/AISI Designations



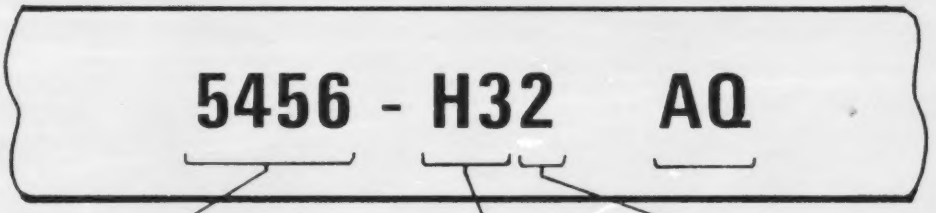
Identification Markings



Aluminum Copper Alloy

Solution heat treated, artificially aged

Aircraft Quality

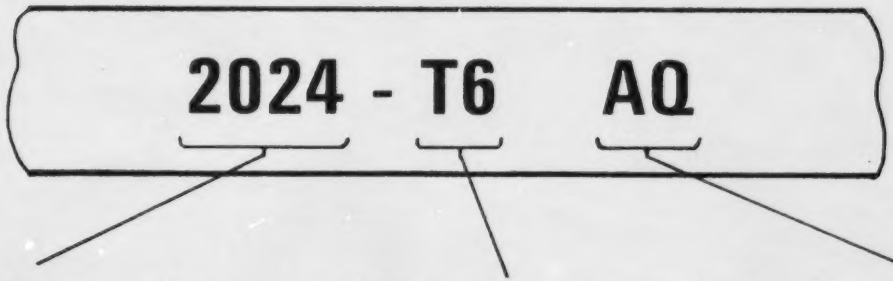


Aluminum-Magnesium Alloy

Strain hardened, then stabilized

¼ hard

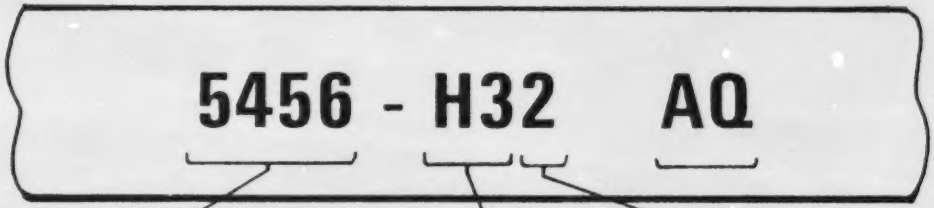
Identification Markings



Aluminum Copper Alloy

Solution heat treated, artificially aged

Aircraft Quality



Aluminum-Magnesium Alloy

Strain hardened, then stabilized

¼ hard

To overcome this problem and to relieve the stresses caused by the welding, the welder follows some simple procedures. These include any or all of the following:

A. Proper edge preparation and fit up. This means making the correct bevels on the edges. Allow a space between the pieces to be joined. Use tack welds. Weld longer welds before the shorter welds.

B. Minimize heat input; weld as rapidly as good welding will allow. Use a skip or intermittent weld. Use the back step method.

C. Preheating. On many pieces, distortion can be controlled by preheating the entire piece or structure, before welding is started.

D. Peening. To help the metal stretch as it cools, peen or tap it lightly as it cools, with the round end of a ball peen hammer.

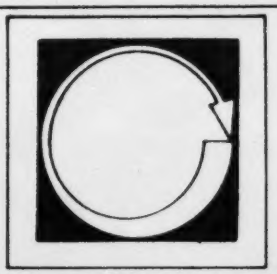
E. Heat Treatment. This finished structure is placed in an oven or furnace capable of uniform heating. The metal soaks in the prescribed temperature, and then is gradually cooled.

F. Jigs and Fixtures. These are devices which hold the pieces of metal rigidly in position during the welding operation, preventing excessive distortion.

G. Number of passes. Distortion can be held to a minimum by using as few passes over the seam as possible.

H. Parts out of position. One of the simplest things to do is to angle the pieces slightly in the opposite direction in which contraction will take place.

Self Assessment



Complete each statement by writing the appropriate phrase in the blanks provided.

1. Most of the metals used in the welding industry are _____.

2. Metals have two types of properties, _____ and _____.

3. The ability of a material to resist being crushed is _____ strength.

4. Metal will _____ when heated.

5. Heating metal causes _____.

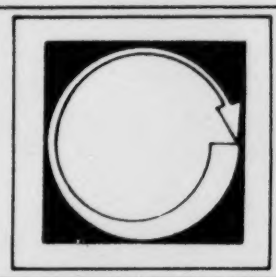
6. Hot rolled bars of metal have a color which is _____.

7. Name two ways to identify metal: _____ and _____.

Self Assessment Answers

1. alloys
2. mechanical, physical
3. compressive
4. expand
5. distortion
6. blue-black
7. appearance, spark test, manufacturer's stamp, color code, magnet reaction, surface filing

Post Assessment



Using the tables that follow, give a metal analysis for each of the numbers listed below. First, locate the SAE number in the left column, then locate and list the AISI number in the column next to it. Locate and list the type of metal it is (from the major chart heading above the various portions of the chart, such as "carbon steels" or "nickle steels."). Locate and lisi the carbon percentage in the third adjacent right column to the SAE number.

1.	1010	2.	1040	3.	1085	4.	1112	5.	1117
6.	2340	7.	4145	8.	5132	9.	8640	10.	9315

	SAE No.	AISI No.	Type	% carbon
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

CARBON STEELS*

SAE NUMBER	1948 AISI NUMBER	CHEMICAL COMPOSITION LIMITS, PERCENT				SAE NUMBER	1948 AISI NUMBER	CHEMICAL COMPOSITION LIMITS, PERCENT			
		CARBON	MANGANESE	PHOSPHORUS	SULFUR			CARBON	MANGANESE	PHOSPHORUS	SULFUR
1008	C 1008	0.10 max	0.25/0.50	0.040	0.050	1041	C 1041	0.36/0.44	1.35/1.65	0.040	0.050
1010	C 1010	0.08/0.13	0.30/0.60	0.040	0.050	1042	C 1042	0.40/0.47	0.60/0.90	0.040	0.050
	C 1012	0.10/0.15	0.30/0.60	0.040	0.050	1043	C 1043	0.40/0.47	0.70/1.00	0.040	0.050
1015	C 1015	0.13/0.18	0.30/0.60	0.040	0.050	1045	C 1045	0.43/0.50	0.60/0.90	0.040	0.050
1016	C 1016	0.13/0.18	0.60/0.90	0.040	0.050	1046	C 1046	0.43/0.50	0.70/1.00	0.040	0.050
1017	C 1017	0.15/0.20	0.30/0.60	0.040	0.050		C 1049	0.46/0.53	0.60/0.90	0.040	0.050
1018	C 1018	0.15/0.20	0.60/0.90	0.040	0.050	1050	C 1050	0.48/0.55	0.60/0.90	0.040	0.050
1019	C 1019	0.15/0.20	0.70/1.00	0.040	0.050	1052	C 1052	0.47/0.55	1.20/1.50	0.040	0.050
1020	C 1020	0.18/0.23	0.30/0.60	0.040	0.050		C 1053	0.48/0.55	0.70/1.00	0.040	0.050
	C 1021	0.18/0.23	0.60/0.90	0.040	0.050	1055	C 1055	0.50/0.60	0.60/0.90	0.040	0.050
1022	C 1022	0.18/0.23	0.70/1.00	0.040	0.050	1060	C 1060	0.55/0.65	0.60/0.90	0.040	0.050
	C 1023	0.20/0.25	0.30/0.60	0.040	0.050	1065	C 1065	0.60/0.70	0.60/0.90	0.040	0.050
1024	C 1024	0.19/0.25	1.35/1.65	0.040	0.050		C 1069	0.65/0.75	0.40/0.70	0.040	0.050
1025	C 1025	0.22/0.28	0.30/0.60	0.040	0.050	1070	C 1070	0.65/0.75	0.60/0.90	0.040	0.050
	C 1026	0.22/0.28	0.60/0.90	0.040	0.050		C 1072	0.65/0.76	1.00/1.30	0.040	0.050
1027	C 1027	0.22/0.29	1.20/1.50	0.040	0.050		C 1075	0.70/0.80	0.40/0.70	0.040	0.050
	C 1029	0.25/0.31	0.60/0.90	0.040	0.050	1078	C 1078	0.72/0.85	0.30/0.60	0.040	0.050
1030	C 1030	0.28/0.34	0.60/0.90	0.040	0.050	1080	C 1080	0.75/0.88	0.60/0.90	0.040	0.050
1033	C 1033	0.30/0.36	0.70/1.00	0.040	0.050		C 1084	0.80/0.93	0.60/0.90	0.040	0.050
1035	C 1035	0.32/0.38	0.60/0.90	0.040	0.050	1085	C 1085	0.80/0.93	0.70/1.00	0.040	0.050
1036	C 1036	0.30/0.37	1.20/1.50	0.040	0.050		C 1086	0.82/0.96	0.30/0.50	0.040	0.050
	C 1037	0.35/0.42	0.40/0.70	0.040	0.050	1090	C 1090	0.85/0.98	0.60/0.90	0.040	0.050
1038	C 1038	0.35/0.42	0.60/0.90	0.040	0.050	1095	C 1095	0.90/1.03	0.30/0.50	0.040	0.050
	C 1039	0.37/0.44	0.70/1.00	0.040	0.050		B 1010	0.13 max	0.30/0.60	0.07/0.12	0.060
1040	C 1040	0.37/0.44	0.60/0.90	0.040	0.050						
		FREE-CUTTING STEELS (OPEN-HEARTH SCREW STEELS)									
	C 1108	0.08/0.13	0.50/0.80	0.040	0.07/0.12		C 1132	0.27/0.34	1.35/1.65	0.040	0.08/0.13
1109	C 1109	0.08/0.13	0.60/0.90	0.040	0.08/0.13	1137	C 1137	0.32/0.39	1.35/1.65	0.040	0.08/0.13
	C 1110	0.08/0.13	0.30/0.60	0.040	0.08/0.13	1138	C 1138	0.34/0.40	0.70/1.00	0.040	0.08/0.13
	C 1118	0.10/0.16	1.00/1.30	0.040	0.24/0.33	1140	C 1140	0.37/0.44	0.70/1.00	0.040	0.08/0.13
1115	C 1115	0.13/0.18	0.60/0.90	0.040	0.08/0.13	1141	C 1141	0.37/0.45	1.35/1.65	0.040	0.08/0.13
1116	C 1116	0.14/0.20	1.10/1.40	0.040	0.16/0.23	1144	C 1144	0.40/0.48	1.35/1.65	0.040	0.24/0.33
1117	C 1117	0.14/0.20	1.00/1.30	0.040	0.08/0.13	1145	C 1145	0.42/0.49	0.70/1.00	0.040	0.04/0.07
1118	C 1118	0.14/0.20	1.30/1.60	0.040	0.08/0.13	1146	C 1146	0.42/0.49	0.70/1.00	0.040	0.08/0.13
1119	C 1119	0.14/0.20	1.00/1.30	0.040	0.24/0.33		C 1148	0.45/0.52	0.70/1.00	0.040	0.04/0.07
1120	C 1120	0.18/0.23	0.70/1.00	0.040	0.08/0.13	1151	C 1151	0.48/0.55	0.70/1.00	0.040	0.08/0.13
	C 1125	0.22/0.28	0.60/0.90	0.040	0.08/0.13						
		FREE-CUTTING STEELS (BESSEMER SCREW STEELS)									
1111	B 1111	0.13 max	0.60/0.90	0.07/0.12	0.08/0.15	1113	B 1113	0.13 max	0.70/1.00	0.07/0.12	0.24/0.33
1112	B 1112	0.13 max	0.70/1.00	0.07/1.00	0.16/0.23						

*From combined standard steel lists of American Iron and Steel Institute and Society of Automotive Engineers, Inc.

ASSIGNMENT SHEET #1

COMBINED STANDARD STEEL TABLE*

SAE NUMBER	1948 AISI NUMBER	CHEMICAL COMPOSITION LIMITS, PERCENT								
		CARBON	MANGANESE	PHOSPHORUS MAX	SULFUR MAX	SILICON	NICKEL	CHROMIUM	MOLYBDENUM	VANADIUM
MANGANESE STEELS (MANGANESE IN ALLOY RANGE)										
1320	1320	0.18/0.23	1.60/1.90	0.040	0.040	0.20/0.35				
	1321	0.17/0.22	1.80/2.10	0.050	0.050	0.20/0.35				
1330	1330	0.28/0.33	1.60/1.90	0.040	0.040	0.20/0.35				
1335	1335	0.33/0.38	1.60/1.90	0.040	0.040	0.20/0.35				
1340	1340	0.38/0.43	1.60/1.90	0.040	0.040	0.20/0.35				
NICKEL STEELS										
2317	2317	0.15/0.20	0.40/0.60	0.040	0.040	0.20/0.35	3.25/3.75			
2330	2330	0.28/0.33	0.60/0.80	0.040	0.040	0.20/0.35	3.25/3.75			
	2335	0.33/0.38	0.60/0.80	0.040	0.040	0.20/0.35	3.25/3.75			
2340	2340	0.38/0.43	0.70/0.90	0.040	0.040	0.20/0.35	3.25/3.75			
2345	2345	0.43/0.48	0.70/0.90	0.040	0.040	0.20/0.35	3.25/3.75			
2512	E 2512	0.09/0.14	0.45/0.60	0.025	0.025	0.20/0.35	4.75/5.25			
2515	2515	0.12/0.17	0.40/0.60	0.040	0.040	0.20/0.35	4.75/5.25			
2517	E 2517	0.15/0.20	0.45/0.60	0.025	0.025	0.20/0.35	4.75/5.25			
NICKEL-CHROMIUM STEELS										
3115	3115	0.13/0.18	0.40/0.60	0.040	0.040	0.20/0.35	1.10/1.40	0.55/0.75		
3120	3120	0.17/0.22	0.60/0.80	0.040	0.040	0.20/0.35	1.10/1.40	0.55/0.75		
3130	3130	0.28/0.33	0.60/0.80	0.040	0.040	0.20/0.35	1.10/1.40	0.55/0.75		
3135	3135	0.33/0.38	0.60/0.80	0.040	0.040	0.20/0.35	1.10/1.40	0.55/0.75		
3140	3140	0.38/0.43	0.70/0.90	0.040	0.040	0.20/0.35	1.10/1.40	0.55/0.75		
3141	3141	0.38/0.43	0.70/0.90	0.040	0.040	0.20/0.35	1.10/1.40	0.70/0.90		
3145	3145	0.43/0.48	0.70/0.90	0.040	0.040	0.20/0.35	1.10/1.40	0.70/0.90		
3150	3150	0.48/0.53	0.70/0.90	0.040	0.040	0.20/0.35	1.10/1.40	0.70/0.90		
3310	E 3310	0.08/0.13	0.45/0.60	0.025	0.025	0.20/0.35	3.25/3.75	1.40/1.75		
3316	E 3316	0.14/0.19	0.45/0.60	0.025	0.025	0.20/0.35	3.25/3.75	1.40/1.75		
MOLYBDENUM STEELS										
4017	4017	0.15/0.20	0.70/0.90	0.040	0.040	0.20/0.35			0.20/0.30	
4023	4023	0.20/0.25	0.70/0.90	0.040	0.040	0.20/0.35			0.20/0.30	
4024	4024	0.20/0.25	0.70/0.90	0.040	0.035/0.050	0.20/0.35			0.20/0.30	
4027	4027	0.25/0.30	0.70/0.90	0.040	0.040	0.20/0.35			0.20/0.30	
4028	4028	0.25/0.30	0.70/0.90	0.040	0.035/0.050	0.20/0.35			0.20/0.30	
4032	4032	0.30/0.35	0.70/0.90	0.040	0.040	0.20/0.35			0.20/0.30	

*From combined standard steel lists of American Iron and Steel Institute and Society of Automotive Engineers, Inc.

COMBINED STANDARD STEEL TABLE (continued)

SAE NUMBER	1948 AISI NUMBER	CHEMICAL COMPOSITION LIMITS, PERCENT								
		CARBON	MANGANESE	PHOSPHORUS MAX	SULFUR MAX	SILICON	NICKEL	CHROMIUM	MOLYBDENUM	VANADIUM
MOLYBDENUM STEELS – CONTINUED										
4037	4037	0.35/0.40	0.70/0.90	0.040	0.040	0.20/0.35			0.20/0.30	
4042	4042	0.40/0.45	0.70/0.90	0.040	0.040	0.20/0.35			0.20/0.30	
4047	4047	0.45/0.50	0.70/0.90	0.040	0.040	0.20/0.35			0.20/0.30	
4053	4053	0.50/0.56	0.75/1.00	0.040	0.040	0.20/0.35			0.20/0.30	
4063	4063	0.60/0.67	0.75/1.00	0.040	0.040	0.20/0.35			0.20/0.30	
4068	4068	0.63/0.70	0.75/1.00	0.040	0.040	0.20/0.35			0.20/0.30	
4130	4130	0.28/0.33	0.40/0.60	0.040	0.040	0.20/0.35		0.80/1.10	0.15/0.25	
	E 4132	0.30/0.35	0.40/0.60	0.025	0.025	0.20/0.35		0.80/1.10	0.18/0.25	
	E 4135	0.33/0.38	0.70/0.90	0.025	0.025	0.20/0.35		0.80/1.10	0.18/0.25	
4137	4137	0.35/0.40	0.70/0.90	0.040	0.040	0.20/0.35		0.80/1.10	0.15/0.25	
	E 4137	0.35/0.40	0.70/0.90	0.025	0.025	0.20/0.35		0.80/1.10	0.18/0.25	
4140	4140	0.38/0.43	0.75/1.00	0.040	0.040	0.20/0.35		0.80/1.10	0.15/0.25	
	4142	0.40/0.45	0.75/1.00	0.040	0.040	0.20/0.35		0.80/1.10	0.15/0.25	
4145	4145	0.43/0.48	0.75/1.00	0.040	0.040	0.20/0.35		0.80/1.10	0.15/0.25	
	4147	0.45/0.50	0.75/1.00	0.040	0.040	0.20/0.35		0.80/1.10	0.15/0.25	
4150	4150	0.48/0.53	0.75/1.00	0.040	0.040	0.20/0.35		0.80/1.10	0.15/0.25	
4317	4317	0.15/0.20	0.45/0.65	0.040	0.040	0.20/0.35	1.65/2.00	0.40/0.60	0.20/0.30	
4320	4320	0.17/0.22	0.45/0.65	0.040	0.040	0.20/0.35	1.65/2.00	0.40/0.60	0.20/0.30	
	4337	0.35/0.40	0.60/0.80	0.040	0.040	0.20/0.35	1.65/2.00	0.70/0.90	0.20/0.30	
4340	4340	0.38/0.43	0.60/0.80	0.040	0.040	0.20/0.35	1.65/2.00	0.70/0.90	0.20/0.30	
4608	4608	0.06/0.11	0.25/0.45	0.040	0.040	0.25 max	1.40/1.75		0.15/0.25	
4615	4615	0.13/0.18	0.45/0.65	0.040	0.040	0.20/0.35	1.65/2.00		0.20/0.30	
4617	E 4617	0.15/0.20	0.45/0.65	0.025	0.025	0.20/0.35	1.65/2.00		0.20/0.27	
4620	4620	0.17/0.22	0.45/0.65	0.040	0.040	0.20/0.35	1.65/2.00		0.20/0.30	
X 4620	X 4620	0.18/0.23	0.50/0.70	0.040	0.040	0.20/0.35	1.65/2.00		0.20/0.30	
	E 4620	0.17/0.22	0.45/0.65	0.025	0.025	0.20/0.35	1.65/2.00		0.20/0.27	
4621	4621	0.18/0.23	0.70/0.90	0.040	0.040	0.20/0.35	1.65/2.00		0.20/0.30	
4640	4640	0.38/0.43	0.60/0.80	0.040	0.040	0.20/0.35	1.65/2.00		0.20/0.30	
	E 4640	0.38/0.43	0.60/0.80	0.025	0.025	0.20/0.35	1.65/2.00	....	0.20/0.27	
4812	4812	0.10/0.15	0.40/0.60	0.040	0.040	0.20/0.35	3.25/3.75		0.20/0.30	
4815	4815	0.13/0.18	0.40/0.60	0.040	0.040	0.20/0.35	3.25/3.75		0.20/0.30	
4817	4817	0.15/0.20	0.40/0.60	0.040	0.040	0.20/0.35	3.25/3.75		0.20/0.30	
4820	4820	0.18/0.23	0.50/0.70	0.040	0.040	0.20/0.35	3.25/3.75		0.20/0.30	

COMBINED STANDARD STEEL TABLE (continued)

SAE NUMBER	1948 AISI NUMBER	CHEMICAL COMPOSITION LIMITS, PERCENT								
		CARBON	MANGANESE	PHOSPHORUS MAX	SULFUR MAX	SILICON	NICKEL	CHROMIUM	MOLYBDENUM	VANADIUM
CHROMIUM STEELS										
5045	5045	0.43/0.48	0.70/0.90	0.040	0.040	0.20/0.35		0.55/0.75		
5046	5046	0.43/0.50	0.75/1.00	0.040	0.040	0.20/0.35		0.20/0.35		
5120	5120	0.17/0.22	0.70/0.90	0.040	0.040	0.20/0.35		0.70/0.90		
5130	5130	0.28/0.33	0.70/0.90	0.040	0.040	0.20/0.35		0.80/1.10		
5132	5132	0.30/0.35	0.60/0.80	0.040	0.040	0.20/0.35		0.75/1.00		
5135	5135	0.33/0.38	0.60/0.80	0.040	0.040	0.20/0.35		0.80/1.05		
5140	5140	0.38/0.43	0.70/0.90	0.040	0.040	0.20/0.35		0.70/0.90		
5145	5145	0.43/0.48	0.70/0.90	0.040	0.040	0.20/0.35		0.70/0.90		
5147	5147	0.45/0.52	0.70/0.95	0.040	0.040	0.20/0.35		0.85/1.15		
5150	5150	0.48/0.53	0.70/0.90	0.040	0.040	0.20/0.35		0.70/0.90		
5152	5152	0.48/0.55	0.70/0.90	0.040	0.040	0.20/0.35		0.90/1.20		
	5160	0.55/0.65	0.75/1.00	0.040	0.040	0.20/0.35		0.70/0.90		
50100	E 50100	0.95/1.10	0.25/0.45	0.025	0.025	0.20/0.35		0.40/0.60		
51100	E 51100	0.95/1.10	0.25/0.45	0.025	0.025	0.20/0.35		0.90/1.15		
52100	E 52100	0.95/1.10	0.25/0.45	0.025	0.025	0.20/0.35		1.30/1.60		
CHROMIUM-VANDIUM STEELS										
	6120	0.17/0.22	0.70/0.90	0.040	0.040	0.20/0.35		0.70/0.90		0.10 min.
	6145	0.43/0.48	0.70/0.90	0.040	0.040	0.20/0.35		0.80/1.10		0.15 min.
6150	6150	0.48/0.53	0.70/0.90	0.040	0.040	0.20/0.35		0.80/1.10		0.15 min.
	6152	0.48/0.55	0.70/0.90	0.040	0.040	0.20/0.35		0.80/1.10		0.10 min.
NICKEL-CHROMIUM-MOLYBDENUM STEELS										
8615	8615	0.13/0.18	0.70/0.90	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	
8617	8617	0.15/0.20	0.70/0.90	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	
8620	8620	0.18/0.23	0.70/0.90	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	
8622	8622	0.20/0.25	0.70/0.90	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	
8625	8625	0.23/0.28	0.70/0.90	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	
8627	8627	0.25/0.30	0.70/0.90	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	
8630	8630	0.28/0.33	0.70/0.90	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	
8632	8632	0.30/0.35	0.70/0.90	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	
8635	8635	0.33/0.38	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	
8637	8637	0.35/0.40	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	
8640	8640	0.38/0.43	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	
8641	8641	0.38/0.43	0.75/1.00	0.040	0.040/0.060	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	

ASSIGNMENT SHEET #1

COMBINED STANDARD STEEL TABLE (continued)

SAE NUMBER	1948 AISI NUMBER	CHEMICAL COMPOSITION LIMITS, PERCENT								
		CARBON	MANGANESE	PHOSPHORUS MAX	SULFUR MAX	SILICON	NICKEL	CHROMIUM	MOLYBDENUM	VANADIUM
NICKEL-CHROMIUM-MOLYBDENUM STEELS—CONTINUED										
8642	8642	0.40/0.45	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	
8645	8645	0.43/0.48	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	
8647	8647	0.45/0.50	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	
8650	8650	0.48/0.53	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.70	0.15/0.25	
8653	8653	0.50/0.56	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.50/0.80	0.15/0.25	
8655	8655	0.50/0.60	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	
8660	8660	0.55/0.65	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	
	8719	0.18/0.23	0.60/0.80	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30	
8720	8720	0.18/0.23	0.70/0.90	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30	
8735	8735	0.33/0.38	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30	
8740	8740	0.38/0.43	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30	
	8742	0.40/0.45	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30	
8745	8745	0.43/0.48	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30	
	8747	0.45/0.50	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30	
8750	8750	0.48/0.53	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30	
9255	9255	0.50/0.60	0.70/0.95	0.040	0.040	1.80/2.20				
9260	9260	0.55/0.65	0.70/1.00	0.040	0.040	1.80/2.20				
9261	9261	0.55/0.65	0.75/1.00	0.040	0.040	1.80/2.20		0.10/0.25		
9262	9262	0.55/0.65	0.75/1.00	0.040	0.040	1.80/2.20		0.25/0.40		
9310	E 9310	0.08/0.13	0.45/0.65	0.025	0.025	0.20/0.35	3.00/3.50	1.00/1.40	0.08/0.15	
9315	E 9315	0.13/0.18	0.45/0.65	0.025	0.025	0.20/0.35	3.00/3.50	1.00/1.40	0.08/0.15	
9317	E 9317	0.15/0.20	0.45/0.65	0.025	0.025	0.20/0.35	3.00/3.50	1.00/1.40	0.08/0.15	
9437	9437	0.35/0.40	0.90/1.20	0.040	0.040	0.20/0.35	0.30/0.60	0.30/0.50	0.08/0.15	
9440	9440	0.38/0.43	0.90/1.20	0.040	0.040	0.20/0.35	0.30/0.60	0.30/0.50	0.08/0.15	
9442	9442	0.40/0.45	1.00/1.30	0.040	0.040	0.20/0.35	0.30/0.60	0.30/0.50	0.08/0.15	
9445	9445	0.43/0.48	1.00/1.30	0.040	0.040	0.20/0.35	0.30/0.60	0.30/0.50	0.08/0.15	
9747	9747	0.45/0.50	0.50/0.80	0.040	0.040	0.20/0.35	0.40/0.70	0.10/0.25	0.15/0.25	
9763	9763	0.60/0.67	0.50/0.80	0.040	0.040	0.20/0.35	0.40/0.70	0.10/0.25	0.15/0.25	
9840	9840	0.38/0.43	0.70/0.90	0.040	0.040	0.20/0.35	0.85/1.15	0.70/0.90	0.20/0.30	
9845	9845	0.43/0.48	0.70/0.90	0.040	0.040	0.20/0.35	0.85/1.15	0.70/0.90	0.20/0.30	
9850	9850	0.48/0.53	0.70/0.90	0.040	0.040	1.20/0.35	0.85/1.15	0.70/0.90	0.20/0.30	

ASSIGNMENT SHEET #1

Rapid Identification of Metals

Metal	Surface Appearance or markings	Reaction to a Magnet	Color of freshly filed surface
White cast iron	Dull gray	Strong	Silvery white
Gray cast iron	Dull gray	Strong	Light silvery gray
Aluminum	Light gray to white dull or brilliant	None	White
Brass	Yellow to green or brown	None	Reddish yellow to yellowish white
Bronze	Red to brown	None	Reddish yellow to yellowish white
Copper	Smooth; red brown to green (oxides)	None	Bright copper color
Copper-nickel	Smooth; gray to yellow or yellowish green	None	Bright silvery white
Lead	White to gray; smooth, velvety	None	White
Nickel	Dark gray; smooth; sometimes green (oxides)	Medium	Bright silvery white
Nickel-copper	Dark gray, smooth	Very slight	Light gray
Plain carbon steel	Dark gray; may be rusty	Strong	Bright silvery gray
Stainless steel (18-8) (25-20) "Note 1 below"	Dark gray; dull to brilliant; usually clean	None (faint if severely cold worked)	Bright silvery gray
Zinc	Whitish blue, may be mottled	None	White

1. Stainless steels that have less than 26 percent alloying elements react to magnet.